WHAT IS CLAIMED IS:

1. A method for determining the temperature of a radiating body utilizing the alexandrite effect, the method comprising the steps of:

receiving radiation from the radiating body;

measuring a spectral power distribution of the radiation;

filtering the spectral power distribution with an alexandrite effect filter;

calculating a hue value based on the spectral power distribution; and

calculating the temperature based on a predetermined mathematical relationship between the hue value and temperature of the alexandrite effect filter.

2. The method according to Claim 1 wherein the alexandrite effect refers to a color change of a material under a blackbody radiator at different temperatures.

3. The method according to Claim 1 wherein the alexandrite effect further refers to a color change of a material under different types of light sources at different color temperature.

4. The method according to Claim 1 wherein the alexandrite effect filter comprises any material that shows the alexandrite effect.

5. The method according to Claim 1 wherein the predetermined mathematical relationship is generated by the steps of:

measuring a spectral transmittance of the alexandrite effect filter along the direction perpendicular to its surface;

calculating hue values for the alexandrite effect filter under a blackbody at different temperatures in a selected color space; and

determining the mathematical relationship between the hue values and corresponding temperatures in the color space in which the hue values are calculated.

6. The method according to Claim 5 wherein the mathematical relationship between the hue value and temperature of the alexandrite effect crystal can be generated in any color space.

7. The method according to Claim 6 wherein the color space is selected from the group consisting of CIELAB, CIELUV, and CIE(x, y), the CIELAB color space being typically selected due to its

uniformity for color perception.

8. The method according to Claim 1 wherein the mathematical relationship between the hue angle and temperature is generated utilizing the following equations in the CIELAB color space:

$$X = \int \bar{x}(\lambda)s(\lambda)P(\lambda)d\lambda$$
$$Y = \int \bar{y}(\lambda)s(\lambda)P(\lambda)d\lambda$$
$$Z = \int \bar{z}(\lambda)s(\lambda)P(\lambda)d\lambda$$

where X, Y, and Z are CIE tristimulus values of the alexandrite effect crystal, $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, and $\bar{z}(\lambda)$ are CIE color-matching functions, $s(\lambda)$ is the spectral power distribution of the radiating body measured, and $P(\lambda)$ is a spectral transmittance of the alexandrite effect filter used;

$$L^* = 116(Y/Y_n)^{1/3} - 16$$
$$a^* = 500\left[\left(X/X_n\right)^{1/3} - \left(Y/Y_n\right)^{1/3}\right]$$
$$b^* = 200\left[\left(Y/Y_n\right)^{1/3} - \left(Z/Z_n\right)^{1/3}\right]$$

where L*, a* and b* are coordinates of CIELAB color space, and X_n, Y_n, and Z_n are the tristimulus values of the measured radiating body;

$$h_{ab} = \arctan(b^*/a^*)$$

where h is the hue angle;

$$T = f(h)$$

where T is the temperature, the temperature being a function of the hue angle h selected from the group consisting of a polynomial function, an exponential function, a logarithmic function, a trigonometric function, and mixtures thereof, wherein the following polynomial equation is typically selected:

$$T = a_0 + a_1 h + a_2 h^2 + \ldots + a_n h^n$$

where a is a parameter in a polynomial function to the n^{th} power of the hue-angle, wherein large values of n correspond to more accuracy of the polynomial function, n being equal to 3 for small temperature ranges, and n being equal to 6 for large temperature ranges.

9. The method according to Claim 8 wherein parameters of the polynomial equation are obtained by regression calculations using data of the hue value versus temperature.

10. The method according to Claim 8 wherein only a long wavelength component of the $\bar{x}(\lambda)$ function is used to calculate the hue value, the used $\bar{x}(\lambda)$ function having actual values from 510 nm to 760 nm and being zero from 380 nm to 510 nm.

11. The method according to Claim 1 wherein the spectral power distribution has a wavelength range from ultraviolet radiation (100 nm) to infrared radiation (5,000 nm).

12. A spectroradiometric apparatus for determining the temperature of a radiating body comprising:

means for receiving radiation from the radiating body;

means for measuring a spectral power distribution of the radiation;

means for filtering the spectral power distribution by a digital alexandrite effect filter;

means for calculating a hue value based on the spectral power distribution and for determining the temperature based on a predetermined mathematical relationship between the hue value and temperature of the alexandrite effect filter; and

means for correcting the spectral power distribution.

13. The spectroradiometric apparatus according to Claim 12 wherein an optical probe receives the radiation directly from the radiating body.

14. The spectroradiometric apparatus according to Claim 12

wherein the optical probe may receive the radiation through a cubic zirconia window installed on the wall of the radiating body measured, such as a combustion chamber.

15. The spectroradiometric apparatus according to Claim 12 wherein the means for measuring the spectral power distribution is selected from the group consisting of a spectroradiometer, spectrophotometer, spectrometer, spectra imaging system and spectral graphic system.

16. The spectroradiometric apparatus according to Claim 12 wherein the alexandrite effect filter is a digital alexandrite effect filter that tabulates spectral transmittance of a selected alexandrite effect crystal, particularly the spectral transmittance measured along the *a* crystallographic axis of the alexandrite crystal with maximum hue change of approximately 180 degrees in the CIELAB color space between the CIE D65 daylight simulator at 6500 K and the CIE standard light source A at 2856 K.

17. The spectroradiometric apparatus according to Claim 12 wherein the means for calculating the hue value and for

determining the temperature based on the predetermined mathematical relationship is a computer program that can be written in any suitable programming language, the computer program utilizing the equations to calculate hue angles in the CIELAB color space:

$$X = \int \bar{x}(\lambda)s(\lambda)P(\lambda)d\lambda$$
$$Y = \int \bar{y}(\lambda)s(\lambda)P(\lambda)d\lambda$$
$$Z = \int \bar{z}(\lambda)s(\lambda)P(\lambda)d\lambda$$

where X, Y, and Z are CIE tristimulus values of the alexandrite effect crystal, $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, and $\bar{z}(\lambda)$ are CIE color-matching functions, $s(\lambda)$ is the spectral power distribution of the radiating body measured, and $P(\lambda)$ is a spectral transmittance of the alexandrite effect filter;

$$L^* = 116(Y / Y_n)^{1/3} - 16$$
$$a^* = 500\left[\left(X / X_n\right)^{1/3} - \left(Y / Y_n\right)^{1/3}\right]$$
$$b^* = 200\left[\left(Y / Y_n\right)^{1/3} - \left(Z / Z_n\right)^{1/3}\right]$$

where L*, a* and b* are coordinates of CIELAB color space, and X_n, Y_n, and Z_n are the tristimulus values of the measured radiating body;

$$h_{ab} = \arctan(b^* / a^*)$$

where h is the hue angle; and

$$T = a_0 + a_1 h + a_2 h^2 + \ldots + a_n h^n$$

where T is the temperature, and *a* is a parameter in a polynomial function to the n^{th} power of the hue-angle, wherein large values of n correspond to more accuracy of the polynomial function, n being equal to 3 for small temperature ranges, and n being equal to 6 for large temperature ranges.

18. The spectroradiometric apparatus according to Claim 12 wherein the means for correcting the spectral power distribution utilizes the equation:

$$C(\lambda) = \frac{S(\lambda)}{S_m(\lambda)}$$

where $C(\lambda)$ is a spectral correction function to compensate for absorption and intrusion radiation, $S(\lambda)$ is a true relative spectral power distribution of the radiating body, and $S_m(\lambda)$ is the measured spectral power distribution of the radiating body.

19. A spectrometric apparatus for determining the temperature of a radiating body comprising:

means for receiving radiation from the radiating body;

an alexandrite effect filter for filtering the received radiation;

means for measuring a spectral power distribution of the radiation; and

means for calculating a hue value based on the filtered spectral power distribution by the alexandrite filter and for determining the temperature based on a predetermined mathematical relationship between the hue value and temperature of the alexandrite effect filter.

20. The spectrometric apparatus according to Claim 19 wherein the predetermined mathematical relationship is generated by the steps of:

measuring a spectral transmittance of the alexandrite effect crystal along a direction perpendicular to its surface;

calculating hue values for the alexandrite effect filter under blackbody at different temperatures; and

determining the relationship between the hue values and corresponding temperatures in the color space in which the hue values are calculated.

21. The spectrometric apparatus according to Claim 19 wherein the means for measuring radiation from the radiating body is selected from the group consisting of a spectrometer or a

spectrophotometer.

22. The spectrometric apparatus according to Claim 19 wherein the means for calculating the hue value and for determining the temperature based on the predetermined mathematical relationship is a computer program that can be written in any suitable programming language, the computer program utilizing the equations:

$$X = \int \bar{x}(\lambda)s(\lambda)P(\lambda)d\lambda$$
$$Y = \int \bar{y}(\lambda)s(\lambda)P(\lambda)d\lambda$$
$$Z = \int \bar{z}(\lambda)s(\lambda)P(\lambda)d\lambda$$

where X, Y, and Z are CIE tristimulus values of the alexandrite effect crystal, $\bar{x}(\lambda)$, $\bar{y}(\lambda)$, and $\bar{z}(\lambda)$ are CIE color-matching functions, $s(\lambda)P(\lambda)$ is the spectral power distribution of the radiation of the radiating body passing through the alexandrite effect filter;

$$L^* = 116(Y/Y_n)^{1/3} - 16$$
$$a^* = 500\left[\left(X/X_n\right)^{1/3} - \left(Y/Y_n\right)^{1/3}\right]$$
$$b^* = 200\left[\left(Y/Y_n\right)^{1/3} - \left(Z/Z_n\right)^{1/3}\right]$$

where L*, a* and b* are coordinates of CIELAB color space, and X_n, Y_n, and Z_n are the tristimulus values of the measured radiating body;

$$h_{ab} = \arctan(b^*/a^*)$$

where h is the hue angle; and

$$T = a_0 + a_1 h + a_2 h^2 + ... + a_n h^n$$

where T is the temperature, and a is a parameter in a polynomial function to the n^{th} power of the hue-angle, wherein large values of n correspond to more accuracy of the polynomial function, n being equal to 3 for small temperature ranges, and n being equal to 6 for large temperature ranges.

23. A colorimetric apparatus for determining the temperature of a radiating body comprising:

means for receiving radiation from the radiating body;

an alexandrite effect filter for filtering the radiation;

means for measuring colorimetric data of the radiation;

means for determining the temperature based on a predetermined mathematical relationship between the hue value and temperature of the alexandrite effect filter.

24. The colorimetric apparatus according to Claim 23 wherein the means for measuring the colorimetric data is a colorimeter.

25. The colorimetric apparatus according to Claim 23 wherein

the predetermined mathematical relationship is generated by the steps of:

measuring a spectral transmittance of an alexandrite effect crystal along a direction perpendicular to its surface;

calculating hue values for the alexandrite effect filter under blackbody at different temperatures; and

determining the relationship between the hue values and corresponding temperatures in the color space in which the hue values are calculated.

26. The colorimetric apparatus according to Claim 23 wherein the means for determining the temperature based on the predetermined mathematical relationship is a computer program that can be written in any suitable programming language, the computer program utilizing the equation to determine the temperature of the radiating body measured:

$$T = a_0 + a_1 h + a_2 h^2 + \ldots + a_n h^n$$

where T is the temperature, and a is a parameter in a polynomial function to the n^{th} power of the hue-angle, wherein large values of n correspond to more accuracy of the polynomial function, n being equal to 3 for small temperature ranges, and n being equal to 6 for large temperature ranges.

27. A cubic zirconia window comprising one layer of cubic zirconia crystal (ZrO_2) stabilized by at least one member of the group consisting of Y_2O_3, MgO and CaO, wherein the cubic zirconia window can be cut into any shape, size, and thickness to fit within a space of the measured radiating body.

28. The cubic zirconia window according to Claim 27 wherein a spectral transmittance of the cubic zirconia window is suitable for temperature measurement.